Carbon Dioxide Measurements in Flow-through Applications – Experiences with the HydroC™-CO_2-FT

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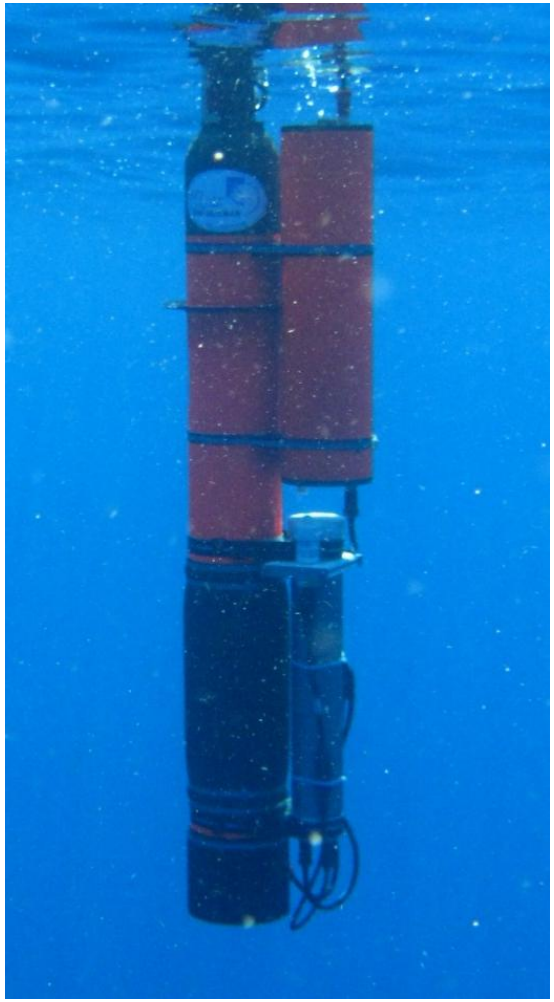
Outline

- Fields of application – CO_2
  - Introduction to the carbonate system
- Connection between platforms and sensors
- Sensor design & measuring principle
- Calibration
- Example data
- Summary



Courtesy of Björn Fiedler, GEOMAR

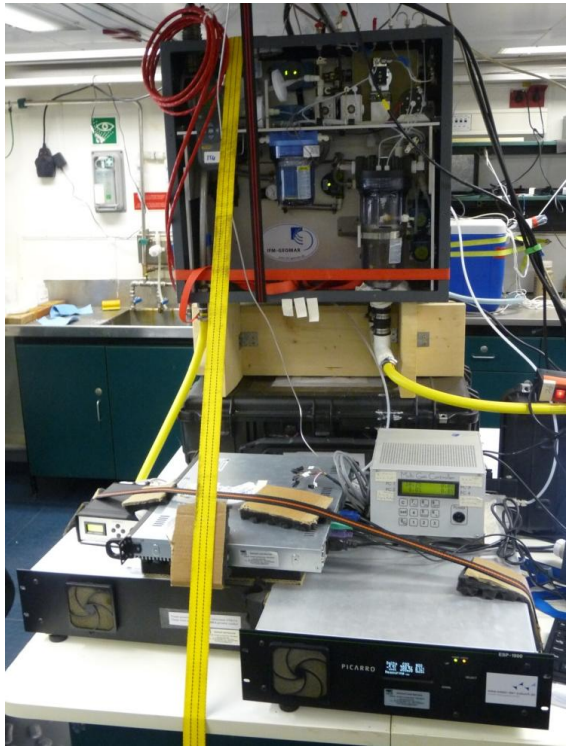
Surface pCO_2/dissolved Gas Measurements

- Underway measurements of pCO_2 → CO_2 fluxes
- <u>Platforms:</u>

  research vessels or volunteering observing ships (VOS);

  buoy installations (seldom)
- <u>Status:</u>

  Mostly individual systems build by or for research institutes
- <u>Keyparts:</u>
  - Equilibrator (various designs)
  - Sensor (mainly IR spectrometry; recently TDLAS/CRDS)



Measuring pCO_2 in a volume of air, which is in equilibrium with the water to be analyzed.

RVs and VOS's

Commercial instrument:
General Oceanics/Neill pCO_2 System

CARBOOCEAN, IFM-GEOMAR contribution

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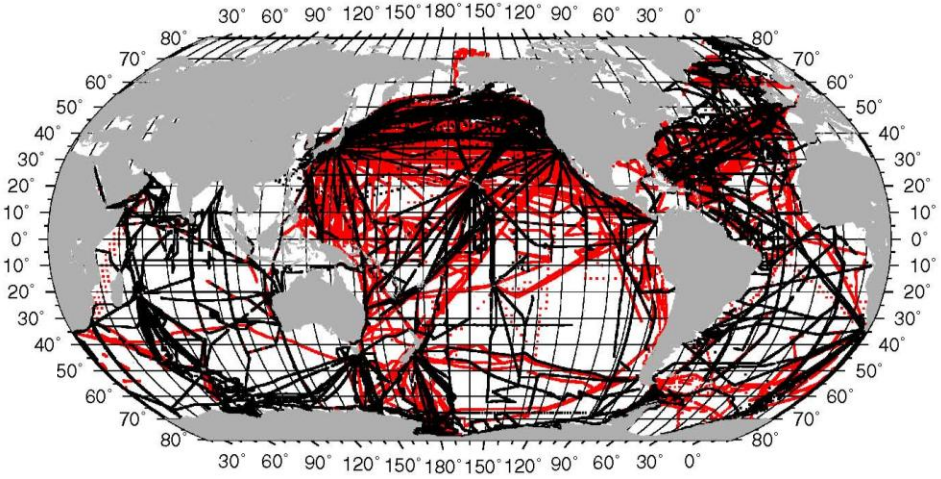
Surface Data – The Challenges

Black:

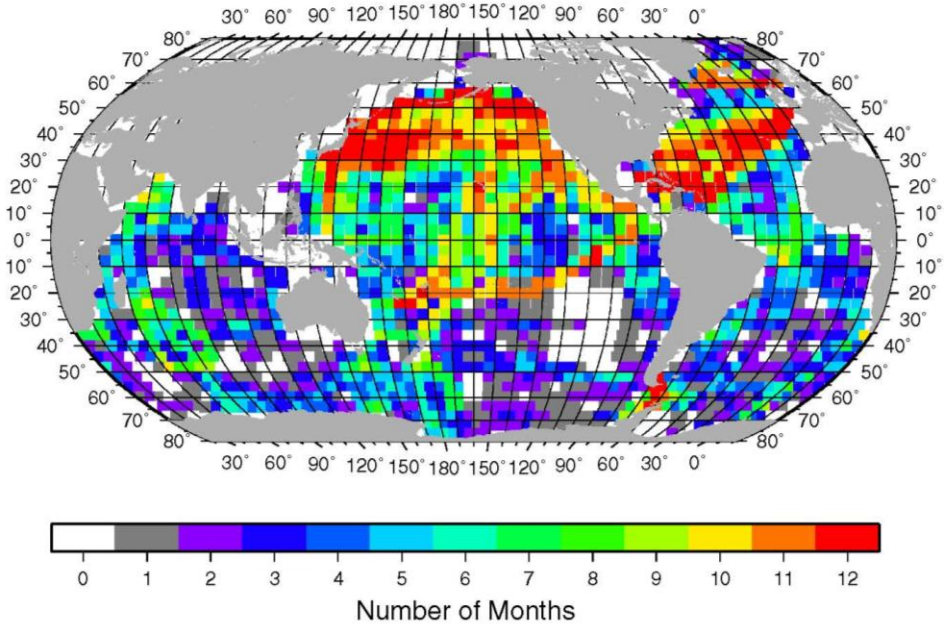
Measurements till 2000 : 0.98 M

Red:

Measurements 1970-2007: 3M



Temporal measurement coverage (4° x 5° boxes)



Source: Takahashi et al. (2008) Climatology

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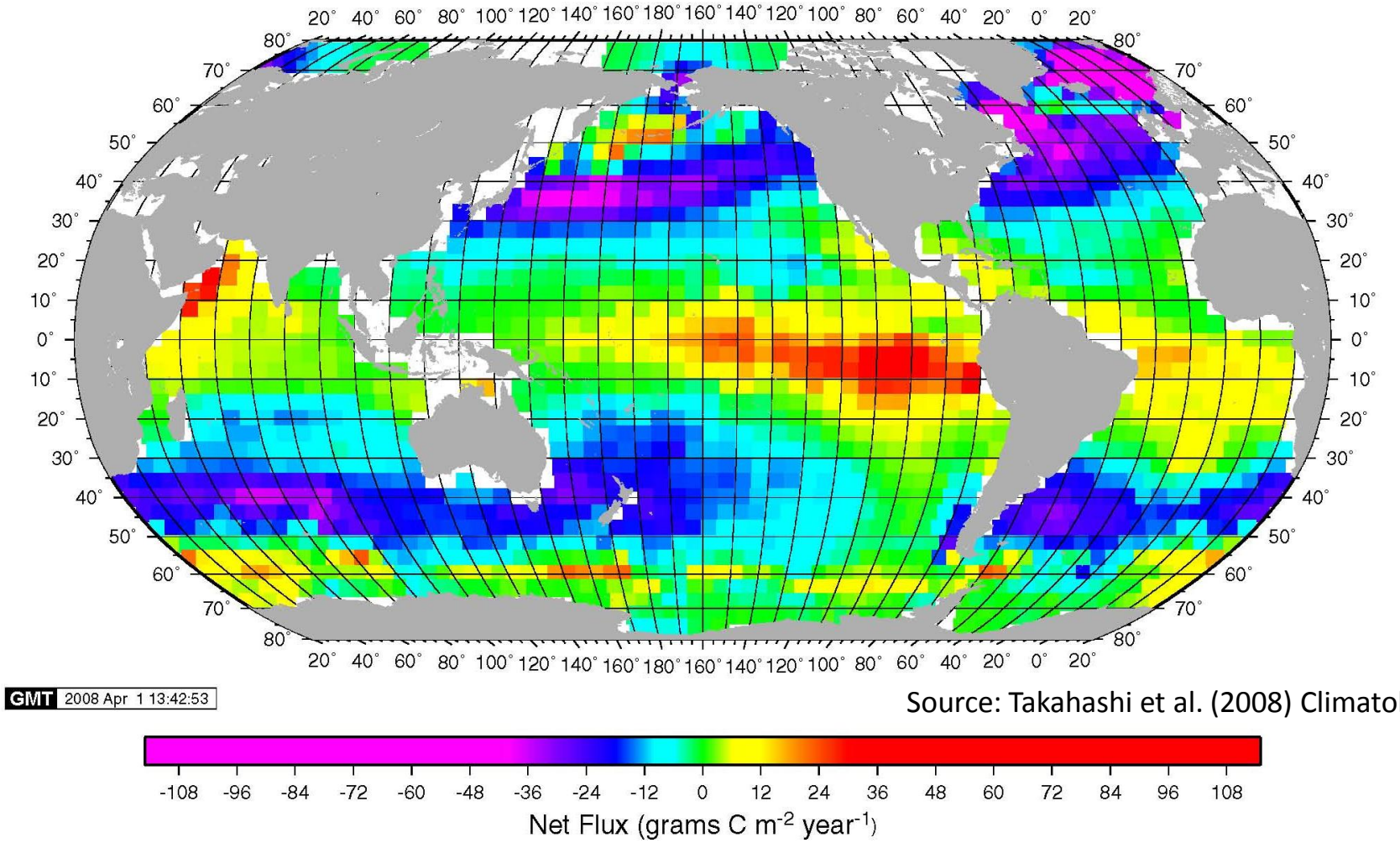
CO_2 Climatology

mean annual sea-air CO_2 flux for the reference year 2000



Source: Takahashi et al. (2008) Climatology

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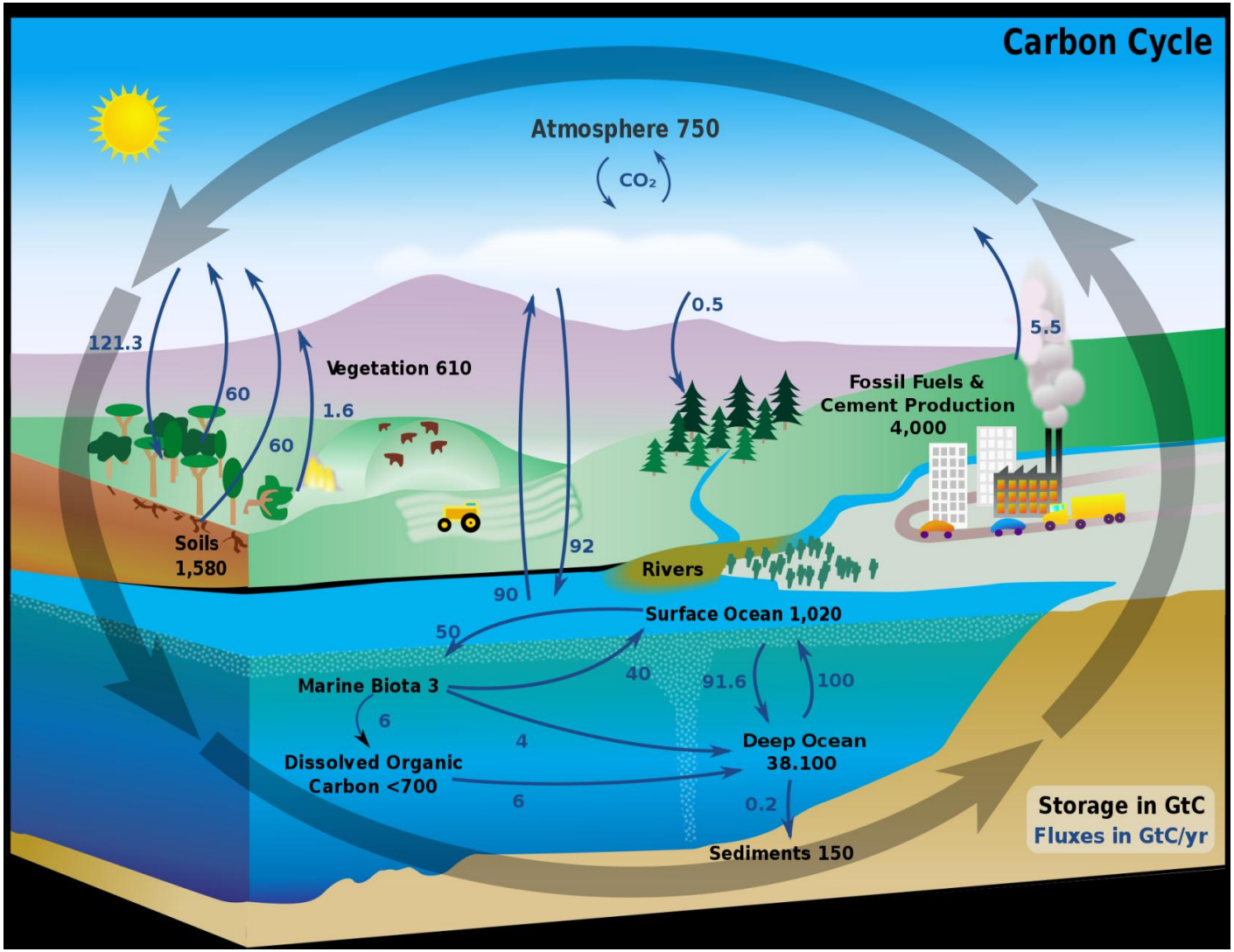
Carbon Cycle – the Ocean Sink



Source: Wikipedia.en, „carbon cycle“

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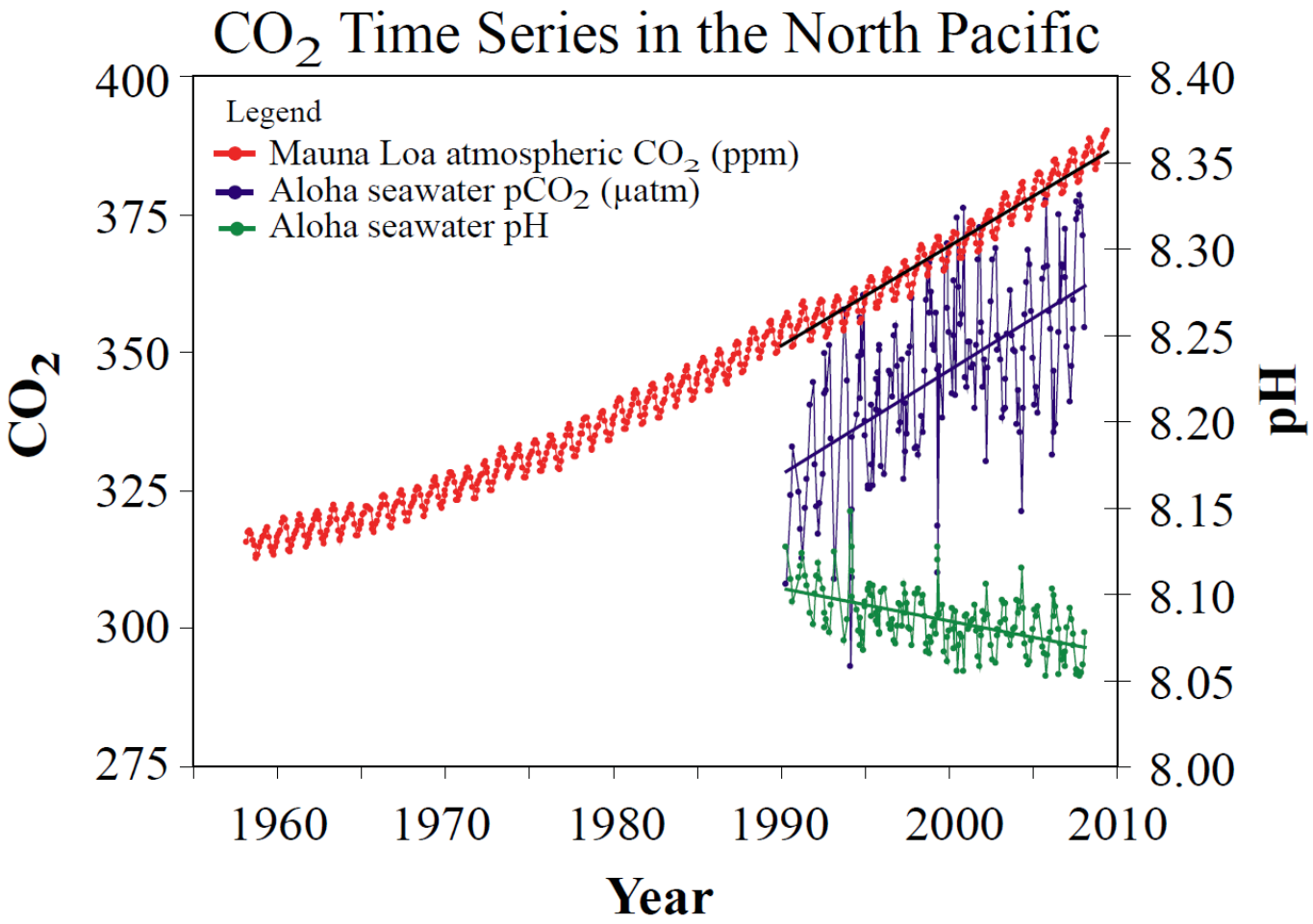
Increase in Atmospheric xCO_2



- 20°N, 156°W
- xCO_2 increase of approx. 1.5 ppm/year
- pH decrease of approx. 0.025 between 1990 and 2010

Source: NOAA Ocean and Great Lakes Acidification Research Plan, 2010

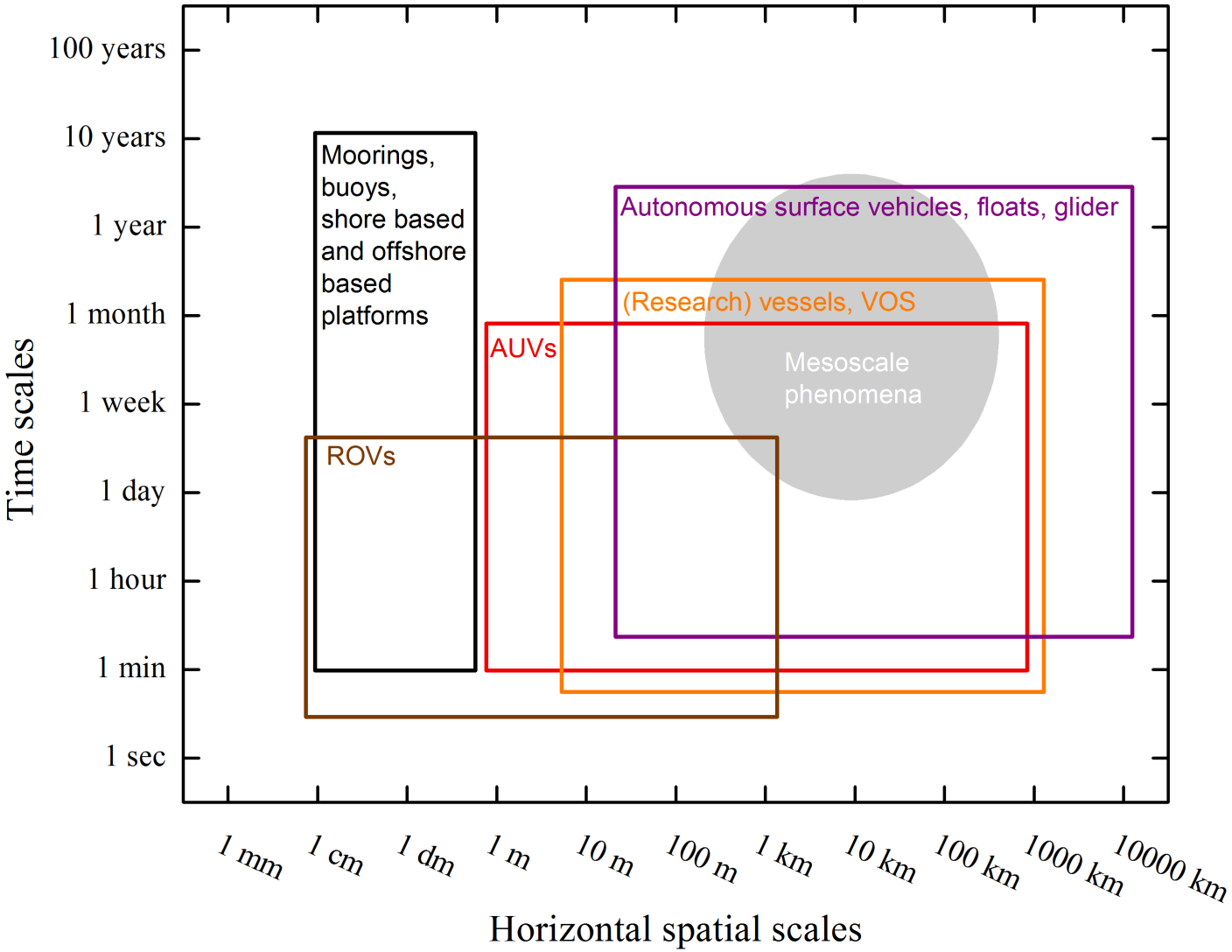
Areas of Application

- **Oceans**
  - Open ocean
    - Surface water
    - Deep sea
  - Coastal regions/estuaries

Source: IOW, Cruise Report RV Sonne, SO196

- **Limnological waters**
  - Lakes
  - Rivers
  - Dammed waters

Platforms



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Actual demands:

- Autonomy
- Mobility
- Versatility
- Cost-efficient data collection

Trends:

→ Modern, mobile platforms

→ VOS

→ Networks

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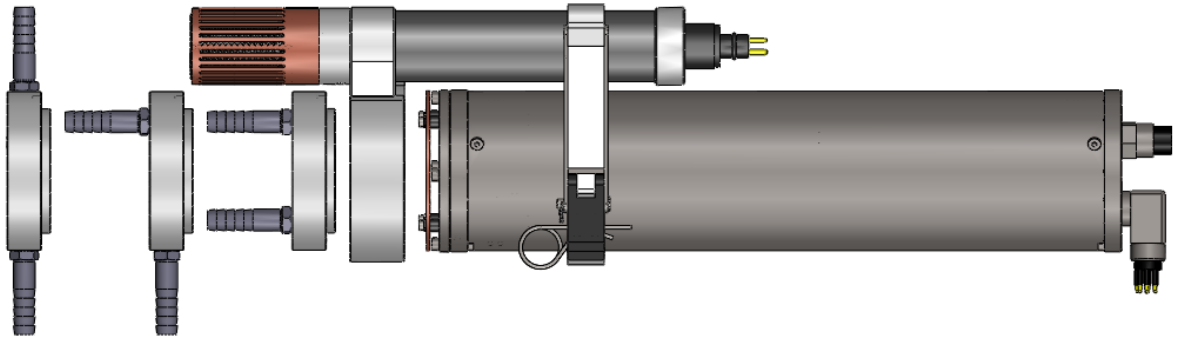
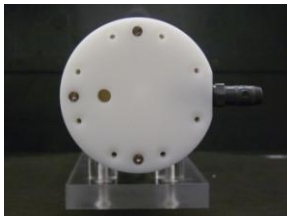
Versatility

Underwater

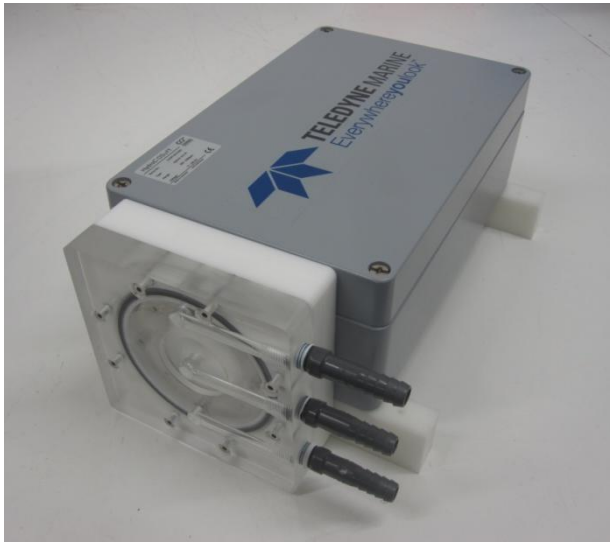
- Flow-Head, Underwater - Flow-through, Protection Cap

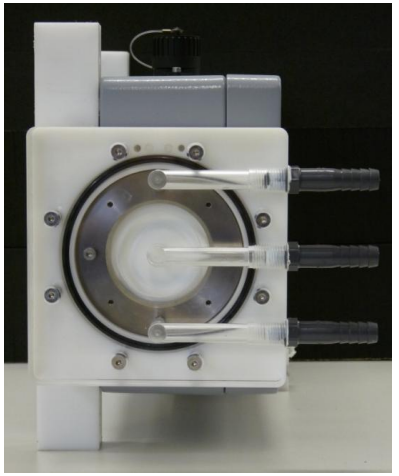




Surface

- Flow-through





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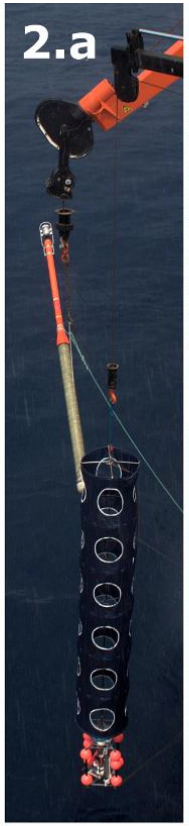

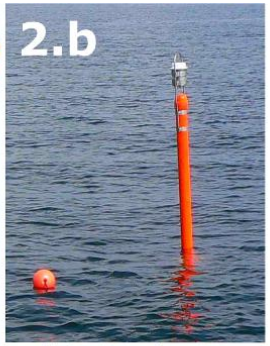

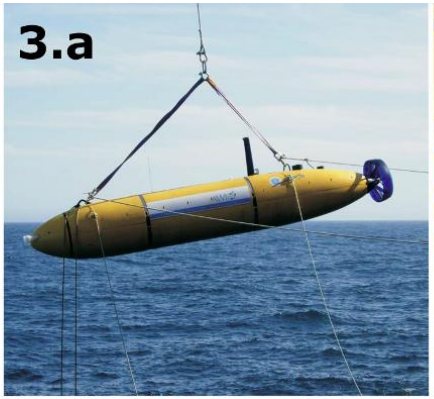

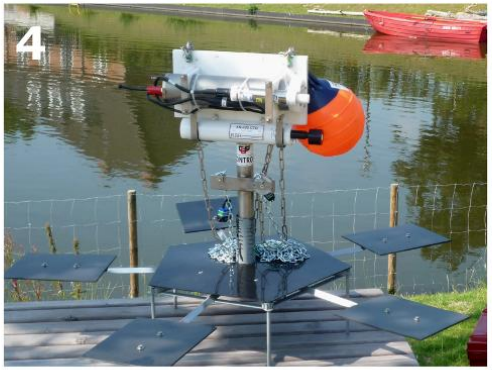

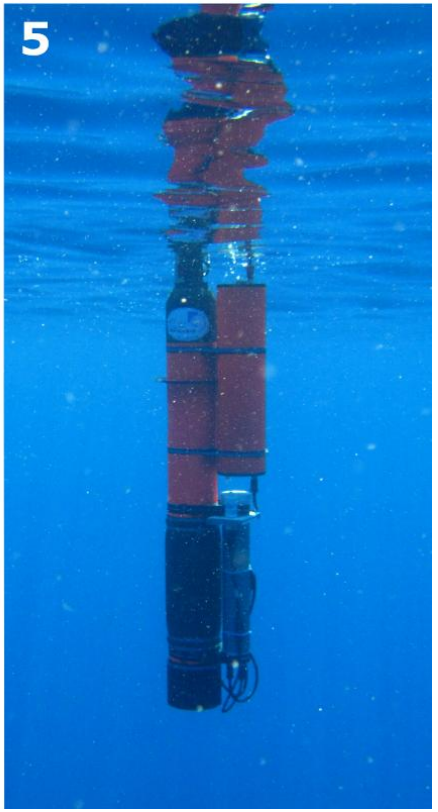

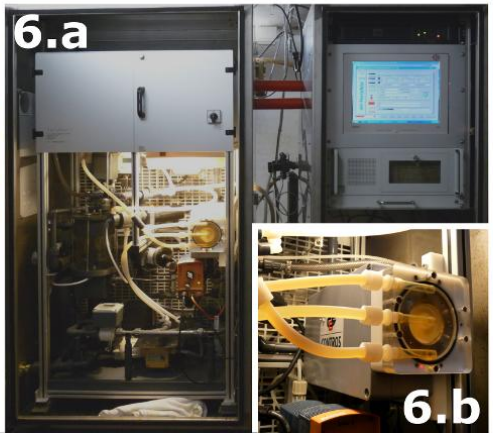

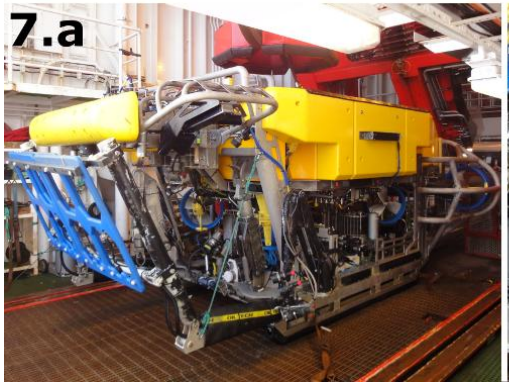

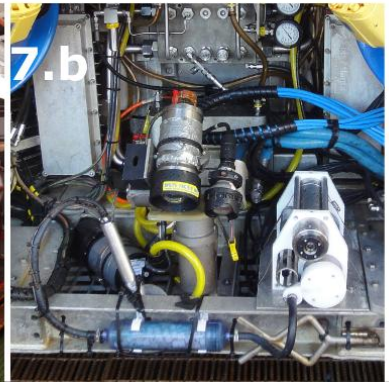

1: Courtesy of Dr. M. Schmidt, IFM-GEOMAR

2.b), 5: Courtesy of B. Fiedler, IFM-GEOMAR

6: Courtesy of 4h-Jena-Engineering

2.a), c): Courtesy of J.Lampel, IFM-GEOMAR

3: Courtesy of T. Wulff, AWI

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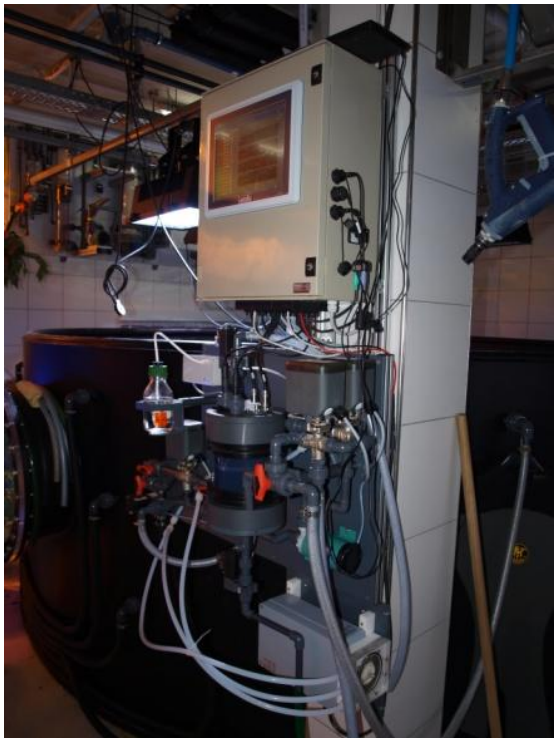
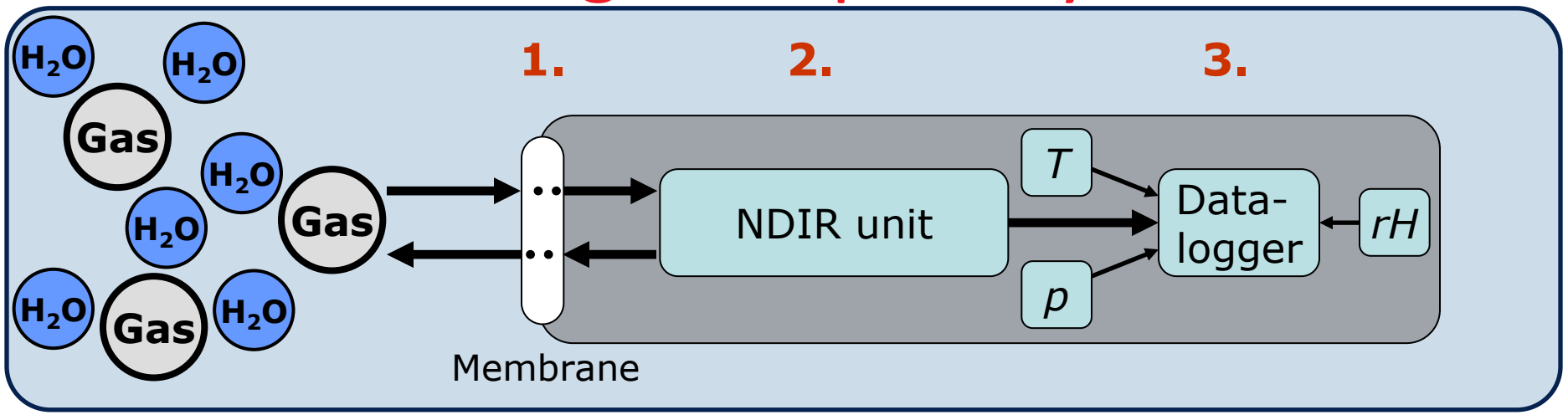
Flow-through Options



Measuring Principle - HydroC™



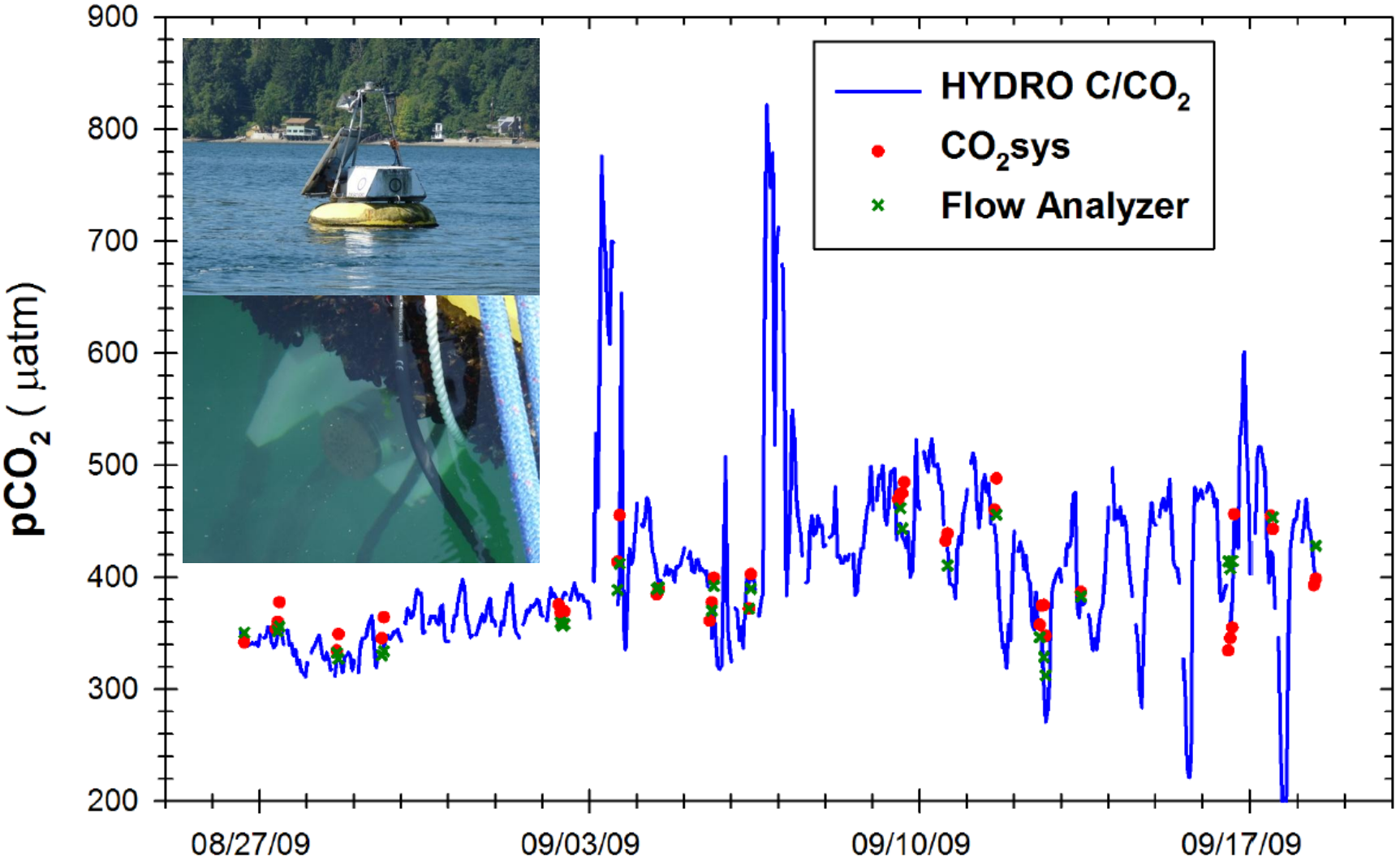
1. Dissolved gasses and water vapor pass hydrophobic membrane

   → Equilibration

2. Gas concentration measured by non-dispersive infrared spectrometry (NDIR) within a gas circuit; Zeroing included (for CO_2 and CH_4)

3. Internal datalogger saves NDIR signals along with *T*, *p* and *rH* (microcontroller and AD-converter)*;* various options for cabled data output

CO_2: Buoy Installation – ACT-Test Seattle



Source: Alliance for Coastal Technology, Performance Demonstration Statement – CONTROS HydroC™/CO_2, www.act-us.info

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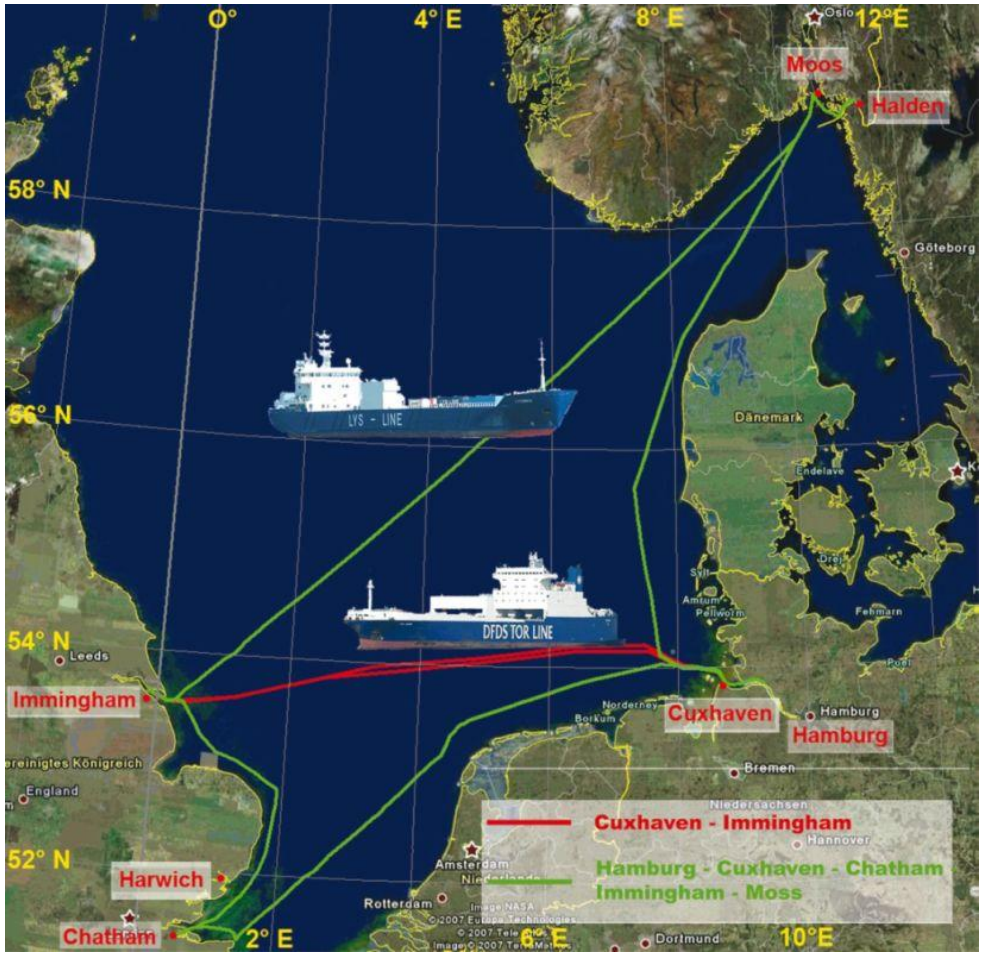
CO_2-FT: HZG-FB – Tor Dania – Cuxhaven-Immingham



Source: http://www.coastalwiki.org/coastalwiki/FerryBox_-_Continuous_and_automatic_water_quality_observations_along_transects

- HydroC™-FT intergated into the FB's on the roll-on/roll-off ship *TorDania* and on the cargo ship *LysBris*

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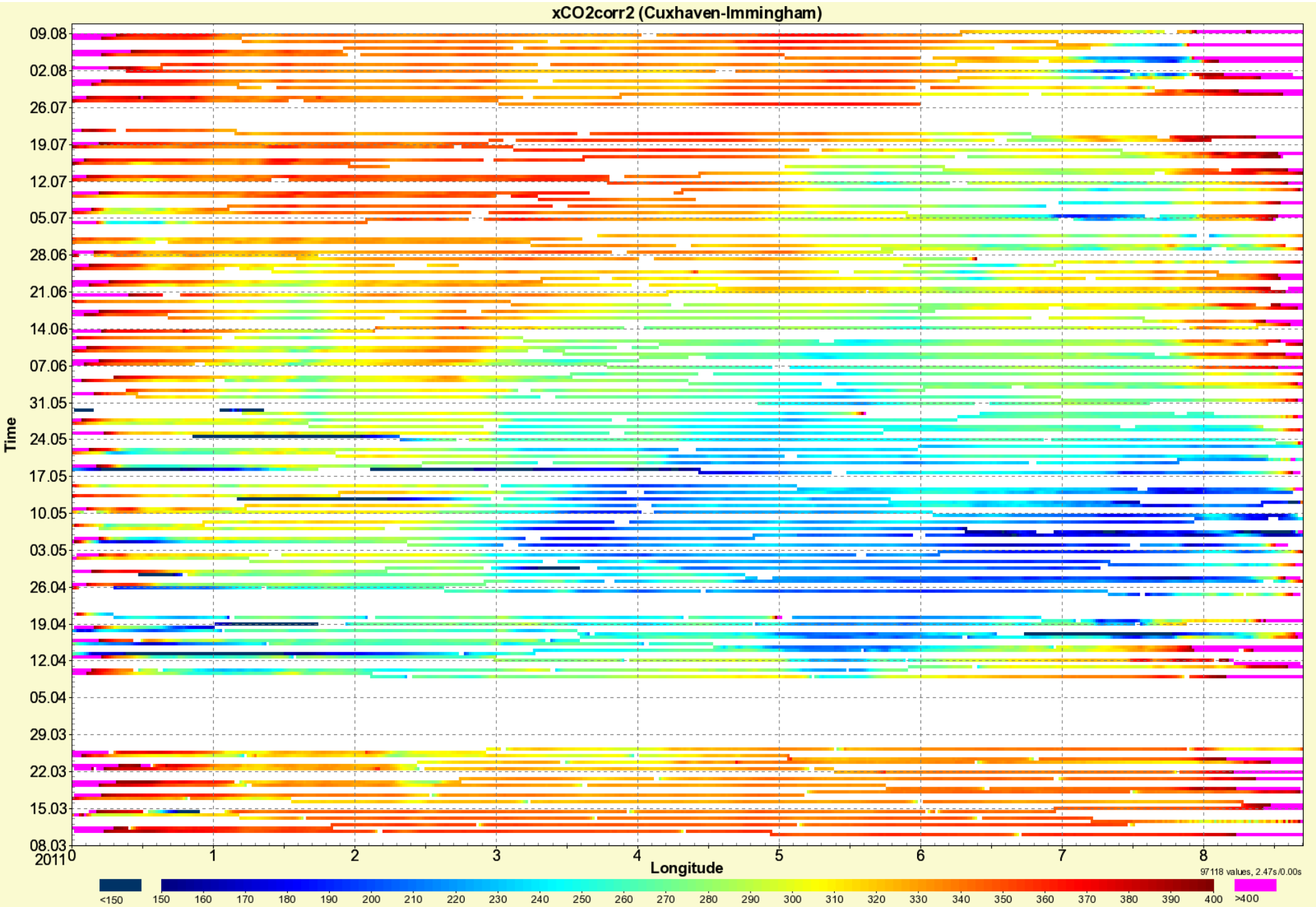

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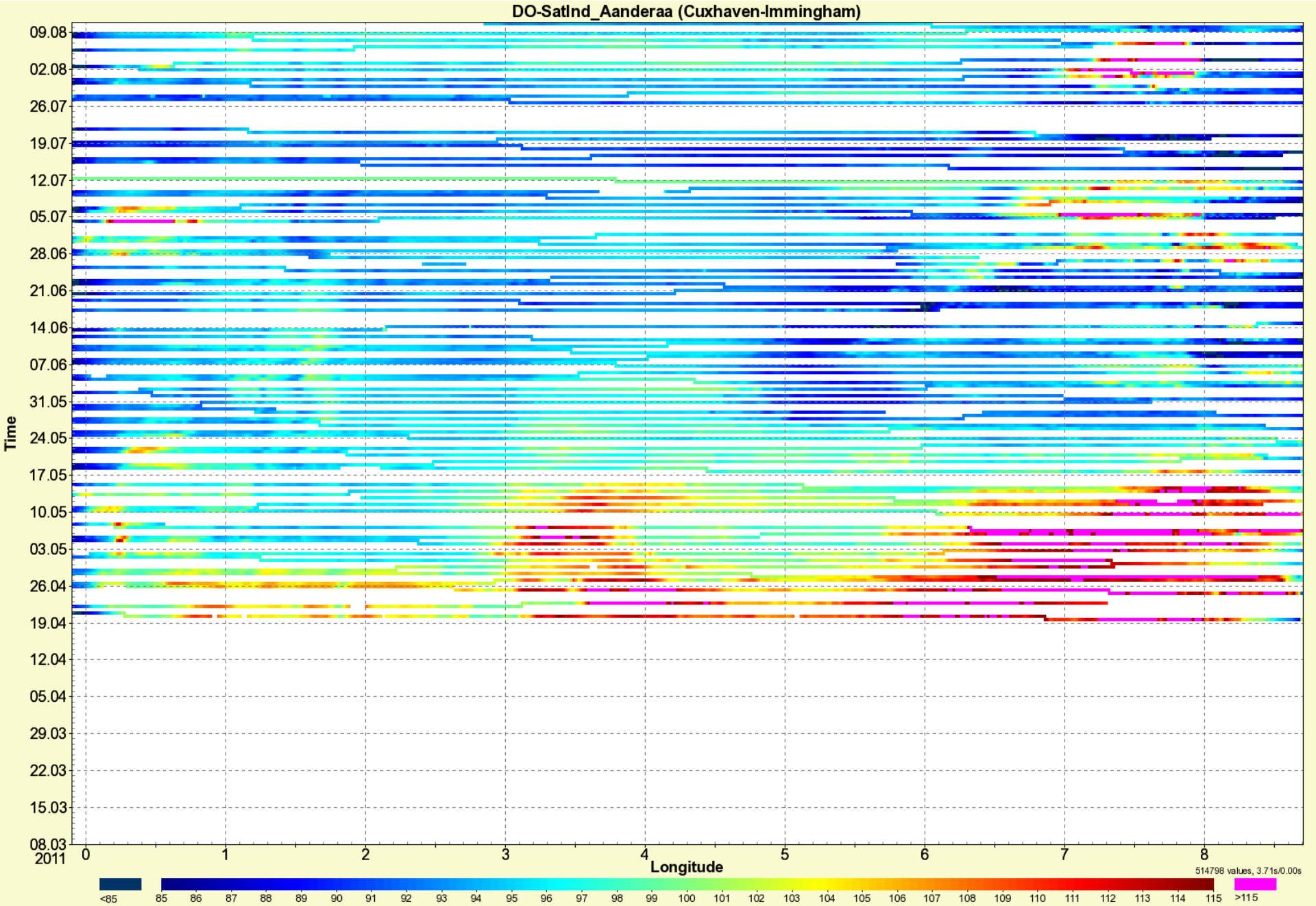
Courtesy of Wilhelm Petersen, Helmholtz-Zentrum Geesthacht



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Summary

- pCO_2 is a parameter of increasing interest that is monitored within numerous applications and on various platforms.

- Dissolved gas measurements = very often multi parameter measurements
  (→ influenced by physical, biological and chemical processes → high variability)
  → measurements together with DO, CTDs, ADCPs, etc.
  → people need to know what to measure

- HydroC™:
  - Reliability proven during many missions and on various platforms.
  - Small, individually in-situ calibrated, fast and including drift correction means.
  - Continuous and direct measurements of dissolved gas parameters.

Thank you

Any questions?

Peer Fietzek, *p.fietzek@contros.eu*